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Servicing is easy with an RCA VoltOhmyst®

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Safety Precautions

An important point to remember is that there is always danger inherent in testing electrical equipment which operates at hazardous voltages. Therefore, the operator should thoroughly familiarize himself with the equipment under test before working on it, bearing in mind that high voltages may appear at unexpected points in defective equipment. Additional precautions which experience in the industry has shown to be important are listed below.

1. It is good practice to remove power before connecting test leads to high-voltage points. If this is impractical, be especially careful to avoid accidental contact with equipment racks and other objects which can provide a ground. Working with one hand in your pocket and standing on a properly insulated floor lessens the danger of shock.

2. Filter capacitors may store a charge large enough to be hazardous. Therefore, discharge filter capacitors before attaching test leads.

3. Remember that leads with broken insulation provide the additional hazard of high voltages appearing at exposed points along the leads. Check test leads for frayed or broken insulation before working with them.

4. To lessen the danger of accidental shock, disconnect test leads immediately after test is completed.

5. Remember that the risk of severe shock is only one of the possible hazards. Even a minor shock can place the operator in hazard of more serious risks such as a bad fall or contact with a source of higher voltage.

6. The experienced operator continuously guards against injury and does not work on hazardous circuits unless another person is available to assist in case of accident.

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Introduction

Of the many types of electronic testing instruments, none is as fundamental or as useful to the electronics technician or engineer as the RCA VoltOhmyst. This widely known and popular instrument is useful in hundreds of different applications in which ac and dc-voltage measurements and resistance measurements must be made.

The VoltOhmyst is especially valuable in servicing such modern electronics equipment as radio receivers and high-fidelity amplifiers, black-and-white and color television receivers, industrial electronics equipment, and electronic-laboratory equipment. The VoltOhmyst is valuable in such applications because it can be used easily and because it has a number of inherent advantages over other types of general-purpose measuring instruments.

On dc-voltage measurements, for example, the VoltOhmyst has an input resistance of 11 megohms on all ranges, an important factor in making measurements in circuits which are sensitive to loading. In addition, the VoltOhmyst can also make dc-voltage measurements in circuits which contain ac voltage without upsetting circuit performance or impairing the accuracy of the dc-voltage reading. Conversely, the VoltOhmyst can be used to make ac-voltage measurements in the presence of dc voltage, an important factor in checking signal voltages in amplifier stages.

The VoltOhmyst's ability to measure resistance values up to 1000 megohms makes it especially valuable for checking the leakage values of capacitors and for testing modern electronics circuits which contain very high resistances.

These basic measurement capabilities make the VoltOhmyst an important trouble-shooting device. Defective equipment, such as a TV receiver, can be checked out in a logical sequence with this single test instrument. AC-voltage measurements with the VoltOhmyst, for example, can be made to check signal levels and power-supply voltages. The ac-voltage checks can then be followed by dc-voltage measurements in individual stages to localize the defective stage or section. When the defective stage or section is located, power can then be removed from the receiver and the VoltOhmyst used to locate the defective component by means of resistance measurements.

These are but a few advantages which the time-tested VoltOhmyst circuitry provides. In addition to the electronic features offered by the dependable VoltOhmyst circuit design, the instrument incorporates many operating and mechanical features which are the result of years of experience by technicians and engineers in all types of electronics work.

If the VoltOhmyst is used properly and with an understanding of the circuit being tested, the instrument can be the most valuable device on the service or laboratory bench. The applications described in this booklet are designed to show the variety of uses in which the VoltOhmyst can be employed. These examples and the principles employed can be used as a guide in trouble shooting other types of circuits. If the few basic measurement principles described here are followed, the operator should be able to use his VoltOhmyst in hundreds of other applications without hesitation or error.

Measurement Tips

Safety and accuracy are first considerations in any type of measurement. Here are some practical suggestions to keep in mind when servicing with a VoltOhmyst.

NEVER attempt to make resistance measurements in circuits to which power is applied. Always remove power from the equipment under test and discharge capacitors in the test circuit before connecting test leads.

When making resistance measurements, always use the scale which gives a reading nearest the center-scale point. Greatest accuracy and readibility will be obtained in the scale region nearest this point.

Tolerance of the resistance used in radio and television receivers is in the order of ± 10 and ± 20 per cent. In most servicing applications it is not necessary, therefore, to measure resistance values to a closer tolerance.

Remember that the voltage of the internal battery of the VoltOhmyst is 1.5 volts. While this value is extremely low, it is possible to damage very low-wattage devices, such as meter multipliers and thermocouples, if the VoltOhmyst is used to make resistance measurements in such special equipment.

When making resistance measurements in complex circuits, it may be very difficult to estimate the total value of the shunt resistance. In such cases, unsolder individual components or break up a complicated circuit by disconnecting major leads and buses. Then check the resistance of parts and simple circuits individually.

Do not leave the ohms lead of the VoltOhmyst shorted to the ground lead for prolonged periods of time. If tests indicate that the internal battery is weak, remove the battery and replace it immediately.

Voltage Measurements

When making tests in a "hot" circuit, always work with one hand in your pocket. Turn off all power to the equipment before connecting test leads. Connect the VoltOhmyst ground lead first and, when handling the probe, keep the fingers away from contact with the probe tip. To minimize electrical shock, connect all test equipment and individual units undergoing test to a common ground.

Transformerless equipment, such as the ac/dc radio receiver, and some television sets, offer an extreme shock hazard. In such equipment, the chassis, ground, or B- buses may be tied to one side of the power line. If the ground cable of the VoltOhmyst is connected to the chassis, the ground circuit in the VoltOhmyst will then be at the same potential as the chassis. With a VoltOhmyst in which the metal case is grounded, the case may be "hot". Always use an isolation transformer such as the RCA Isotap.

High-resistance high-impedance circuits are usually sensitive to resistive and capacitive loading. The isolating resistor in the dc probe of the VoltOhmyst aids in reducing the capacitive loading upon the test circuit. Always use the dc probe when making dc measurements.

Greatest accuracy on both ac and dc voltage measurements is usually obtained in the upper third of each scale. Always use the scale or range which will give a reading nearest the full-scale point on the meter.

AC-voltage measurements should not be a problem if the following factors are kept in mind:

1. The shape and repetition rate of the voltage waveform being measured have a direct effect on the accuracy of the meter indication.

2. While the VoltOhmysts have a very wide frequency response range, the range is not unlimited.

Waveforms which are narrow in shape and have a low repetition rate usually cannot be measured accurately. Attempts to measure ac signals which have higher frequencies than those which the VoltOhmysts are designed to handle may also lead to erroneous readings. Check the "Specifications" section in the instruction booklet supplied with your VoltOhmyst for the frequency response of your instrument.

Direct-Current Measurements

Most VoltOhmysts have no provision for measuring current. Those that can measure current do not have electronic protection against meter damage. Current measurements require several precautions not usually necessary for other measurements. These precautions are recommended to protect the meter from burnout and to protect the technician from electrical shock. They may be summarized briefly as follows:

1. Take special care in setting up the instrument and the test circuit because the meter is not protected against burnout on current measurements.
2. Do not attempt to measure current in circuits in which the ground lead cannot be kept at or near ground potential. Do not attempt to measure alternating current.
3. Always remove power from equipment under test before connecting test leads. Discharge all capacitors in the test circuit.
4. To protect the meter against possible damage, select a range which can accommodate a current of at least twice the value of the estimated current. After power has been applied to the test circuit, set the range switch to a setting which gives a reading nearest to the full-scale point on the meter.

Testing and Troubleshooting Components

Before proceeding with an actual check of the components, it is advisable to make a thorough physical inspection of the equipment. Sometimes a charred resistor or wax from a capacitor or transformer will indicate a defective component. Since a defective component may not show a physical change, no components should be free from suspicion just because it looks right. Most of the time the "tough" set is tough only because a component which was previously improperly checked is at fault. Remember that a defective component in one circuit may affect operation in other circuits. For example, a defective coupling capacitor in an agc-controlled if amplifier affects the voltage on the agc bus and consequently on the grids of all the tubes connected to the bus.

Capacitors, resistors, coils, and other components can be checked in different ways with a Volt-Ohmyst. The methods employed for any individual type of component are the same, however, regardless of the type of equipment in which the part is used.

Capacitors

Capacitor troubles can be divided into three categories: (1) shorted (2) leaky and (3) open. Shorted and leaky capacitors are usually detected by resistance measurements. An open capacitor is usually best discovered by substitution of a new capacitor in place of, or across, the suspected part.

Shorted capacitors are generally the easiest to detect because a short may reduce the internal resistance to zero or to a few hundred ohms. Where a short is suspected, connect the VoltOhmyst directly across the part in the circuit. To pinpoint a leaky capacitor, disconnect the part from the circuit before taking a measurement. Disconnection is usually necessary because other capacitors and resistors in the circuit provide shunt resistance around the part being tested. A positive check can be had by disconnecting one or both ends of the capacitor and measuring the resistance across the part.

The shorted capacitor can also be detected by voltage measurements. In any plate, screen, cathode, or grid-return circuit which uses a bypass capacitor, some voltage usually can be measured across the bypass capacitor. If no voltage is present, or if the voltage is considerably lower than normal, disconnect the capacitor from the circuit and measure its resistance. If voltage returns to the circuit after the part is disconnected, a shorted capacitor

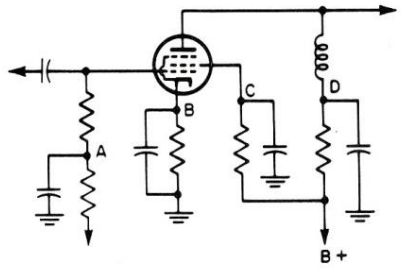


Figure 1. Voltage test points in a typical amplifier.

is indicated. The voltage test points in a typical amplifier circuit are indicated by the letters A, B, C, and D in Figure 1.

When a plate or screen circuit capacitor becomes shorted, excessive current may flow through any resistor connected in series between the capacitor and the voltage source. In such a case, always check out adjacent components with the Volt-Ohmyst to make sure that other parts have not been damaged.

A shorted or leaky coupling capacitor can be detected by dc-voltage measurements. A leaking coupling capacitor, for example, will usually result in an abnormal voltage on the grid of the stage being driven. The voltage may be higher or lower than normal.

In some cases, defective capacitors may be very difficult to detect because the short or leak may not show up until after the full circuit voltage is impressed across the part. For example, a plate or screen bypass capacitor may show infinite resistance when checked with the VoltOhmyst, which applies only 1.5 volts on resistance checks. But, the capacitor may break down quickly when 200 or 300 volts are applied. Defects of this type can be discovered by monitoring the dc voltage across the suspected capacitor with the VoltOhmyst. When the short or leak develops, the voltage reading should drop noticeably.

One method of detecting a leaky coupling capacitor is to measure the dc voltage across the part

while the capacitor is connected into an operating circuit. The check is made as shown in Figure 2. Remove the tube (V2) from its socket and connect the dc probe to the grid pin of the driven stage. If any dc voltage is present, the capacitor is leaking.

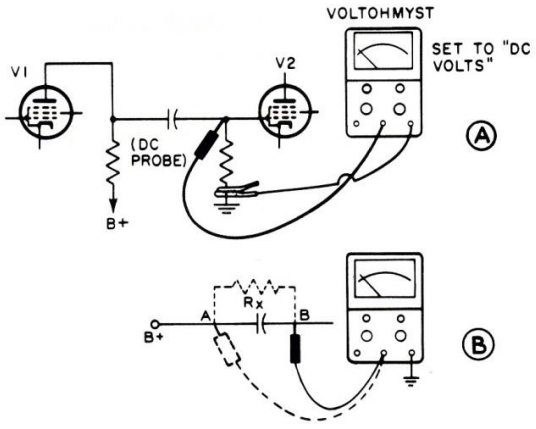


Figure 2. Detecting leaky capacitors: a—In-circuit check. b—Measuring leakage resistance.

Another method which is extremely effective for checking leakage is shown in Figure 2B. One side of the capacitor is connected to B+. The other side to the dc probe of the VoltOhmyst. The VoltOhmyst should be set up to measure the full B+ voltage. Where possible, select a value of the B+ voltage which is approximately equal to the rated voltage of the capacitor. If the capacitor is "good" the meter pointer will deflect upscale and then return to the zero point. The range switch can then be changed to successive lower ranges until the actual leakage voltage can be read.

The approximate leakage resistance, R_x, may be found as follows:

1. Connect the capacitor to B+ as shown in Figure 2B.
2. Measure the B+ voltage, point A.
3. Measure the voltage at point B.
4. Calculate the leakage resistance from the following formula

$$R_x \text{ (megohms)} = \frac{11 \text{ (Volts at A} - \text{Volts at B)}}{\text{Volts at B}}$$

Open capacitors are best detected by temporarily connecting a good capacitor across each of the suspected capacitors (see Figure 3) while the receiver is in operation and noting the effect on receiver

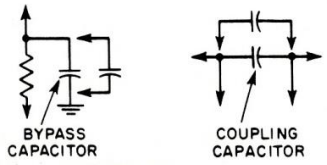


Figure 3. Substitution test for an open capacitor.

operation. If connection of the new capacitor restores the receiver to normal operation, it may be assumed that the original capacitor is open.

Resistors

Fixed composition resistors may change value because of excessive current loads or aging. Use the VoltOhmyst to check the actual value of the resistor after first disconnecting one end of the resistor from the circuit to eliminate the effects of shunt resistance.

Intermittent resistors may be detected by using the VoltOhmyst to monitor the voltage in the circuit, as shown in Figure 4. If the resistors in the circuit are functioning correctly, the voltages will be normal. If a resistor should open up because of heating, the voltage will change or disappear at the test point. Defective voltage-dropping resistors should not be replaced until it has been determined that no other components associated with the circuit are defective.

Coils and Transformers

The most commonly encountered troubles with these components are: (1) open windings (2) shorted turns and (3) shorts and leakage between windings or to the shell, core or ground. Unless the trouble is intermittent, open windings are the easiest to detect. A permanently open coil or transformer may be found easily by resistance and voltage measurements.

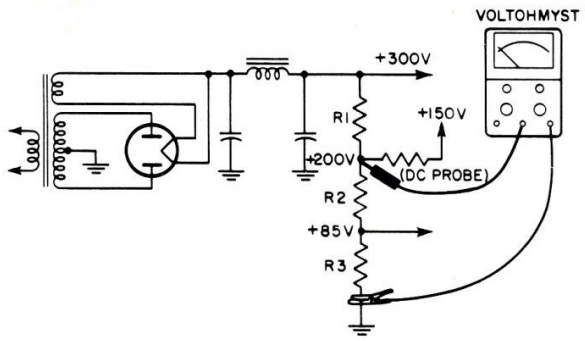


Figure 4. Test setup for monitoring voltage.

A partial or severe short in a coil or transformer winding may be detected by resistance measurements, provided the normal resistance of the winding is known. Resistance checks with the VoltOhmyst are valuable in revealing open windings, shorted coils, and shorts across about 20 per cent or more of the turns of a transformer. Shorted turns may or may not be difficult to detect, depending upon the normal resistance of the windings and the function of the part in the circuit.

Shorts and leakage between windings and the core, shell, or ground are best discovered by resistance measurements. The VoltOhmyst is especially useful in these applications because of its ability to read very high resistances. To check a transformer, disconnect the unit from the circuit and take resistance readings from each winding to the case, core, chassis and to all other windings. In cases where suspected leakage cannot be detected with the VoltOhmyst, a high test voltage can be used to break down the leakage resistance, as shown in Figure 5. With the voltage supply connected to one end of the resistance, take dc voltage

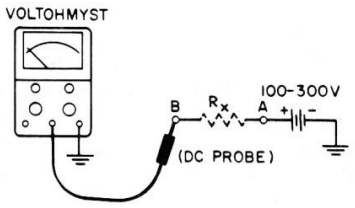


Figure 5. Test setup for checking leakage resistance.

readings at points A and B. The resistance can then be computed by Ohm's law as follows:

$$R_x = \frac{R_{in}\ (\text{volts at A} - \text{volts at B})}{\text{Volts at B}}$$

Power supply filter chokes, vertical deflection output transformers and audio output transformers can be checked by measuring the dc resistance of the windings and employing some of the same tests just mentioned.

TV Troubleshooting

TV troubleshooting offers the greatest variety of applications for the VoltOhmyst. Voltage and resistance measurements remain the best means of quickly locating a faulty stage or defective component. Remember, however, that the best test instrument obtainable is not a substitute for expert servicing technique. Intelligent analysis of receiver performance is a necessary first step in determining which section of the receiver is defective. Before using the VoltOhmyst, therefore, check out the receiver performance carefully and try to determine which receiver section is defective by observing effects on the picture-tube screen and by checking audio performance.

If it is necessary to remove the chassis, first, disconnect the power cord and discharge the high-voltage filter capacitor. Remember that in some receivers, the conductive coating on the picture tube serves as the high-voltage capacitor. If the suspected component cannot be located immediately, proceed with an operating voltage check. Whenever possible, operate the receiver with the picture tube and yoke connected.

Correct circuit operating voltages are shown in the manufacturers' service notes. A variation of $\pm 20\%$ from these voltages should be considered acceptable. Begin the voltage check by measuring the B+ voltages at the output from the power supply. If B+ is low, check the line voltage, rectifiers, and filter circuits. If B+ is high, check for high line voltage, an open bleeder resistor, or for a defective component elsewhere in the receiver which may have reduced the load on the power supply.

Several B+ buses may be used in the receiver. The highest voltages are used in the sweep and audio circuits; the lowest voltages are used in the tuner and if-amplifier sections.

After checking the power supply voltages, measure operating voltages in the suspected section or stage. Abnormally low voltage may indicate a leaky or shorted capacitor or a changed-value resistor. Too high a voltage can point to an open bleeder resistor, or to a shorted dropping resistor.

AGC-Circuit Troubles

AGC-circuit troubles may be difficult to diagnose because of their wide variety of symptoms. The agc stage is fed from the second detector or from the video amplifier and, in keyed agc systems, a signal is also tapped off the high-voltage transformer and fed back to the agc amplifier. The rectified output voltage from the agc stage is usually applied through one or more buses to the grid of the rf-amplifier in the tuner and to the grids of the first and second picture-if amplifiers. Improper bias on these buses can affect both the picture and the sound.

A keyed agc rectifier stage is shown in simplified form in Figure 6.

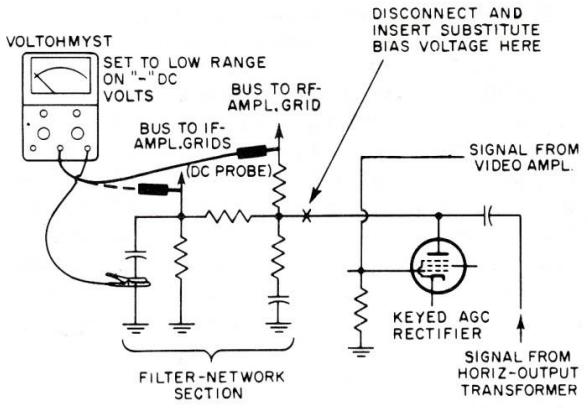


Figure 6. Simplified diagram of a keyed-agc circuit.

Normal voltage on the agc buses may run from zero to several volts. To check agc voltage, set up the VoltOhmyst on a low dc voltage range (—VOLTS) and measure the voltage on the tuner and if-amplifier buses. If these measurements fail to give a positive indication of the trouble, apply an adjustable bias to the buses, after first disconnecting them from the agc rectifier stage. A bias supply such as the RCA WG-307A may be used.

With bias applied, connect the VoltOhmyst to a point which shows abnormal B voltage. Tune in a station on the receiver and set controls to their normal settings. Adjust the bias from the substitute bias supply while watching the reading on the VoltOhmyst. If proper picture and sound performance are restored with normal bias voltage, as indicated on the VoltOhmyst, check out the components in the agc rectifier stage by taking resistance and dc-voltage measurements.

TV Tuners

Voltage and resistance checks of tuners can be made without disassembling or removing the tuner from the chassis. Filament voltages, the agc voltage to the rf amplifier, and the B+ voltage can be checked at the terminal strip adjacent to or mounted on the tuner. When tuner trouble is encountered, make voltage measurements at these terminals first. If the VoltOhmyst indicates abnormal voltage, turn off the power to the receiver and make resistance measurements to ground. If necessary, unsolder the voltage leads at the terminal strip.

Picture-and Sound-IF Amplifiers

The VoltOhmysts are especially suited to trouble-shooting the high-impedance circuits found in picture- and sound-if amplifiers. The simplified diagram shown in Figure 7, for example, shows the locations of various test points at which the VoltOhmyst can be used.

In nearly all television receivers, voltage measurements are made with respect to the chassis. The VoltOhmyst can be used to make measurements of the ac and dc-voltages and resistance values in both the picture- and sound-if amplifiers. In checking out any amplifier stages, it is always wise to first check the filament voltage in cases where stage gain is weak or signal troubles are encountered. This check is often overlooked, although it is quickly made. The VoltOhmyst should then be set up for +DC voltage measurements and the B+ voltage checked at the screen-and plate-circuit junction points. In the circuit of Figure 7, the B+ should also be checked right at the tube pins, as shown by points C, D, I, H, W, L, Q, and R. Grid-bias voltage is usually specified by the manufacturer in his service notes as being measured from grid to chassis ground. The bias should appear in the circuit of Figure 7 at points A, J, and O. It should be remembered that these high-frequency circuits have a relatively high impedance and are, consequently, sensitive to loading. In some cases, connection of any type of test instrument, including a VoltOhmyst, may upset the normal circuit operation. In such cases, it is often possible to check the voltage at a different point which will not upset normal circuit operation. In the first picture if-amplifier stage, shown in Figure 7, the bias voltage may also be measured at point E, which is at rf-ground potential.

In general, it is not possible to signal trace in the low-level stages of such amplifiers because the signal amplitude is too low to be measured with any conventional service instrument.

Grid bias is almost always a negative voltage with respect to the chassis. Cathode bias is always positive and, in Figure 7, is measured at points B, G, K, and P. The polarity of the voltages measured across the crystal-diode detector will depend upon how the diode is connected into the circuit. In the example shown, no voltage would be measured at point M and a very small positive voltage would appear at point N.

If the ratio-detector transformer is properly aligned, equal dc voltages of opposite polarity should be measured at points S and T.

It should be remembered that an inoperative stage in either the picture- or sound- if amplifiers can upset circuit operation in any following stages. Very often, the defective condition can cause two or more stages to appear to be defective because of abnormal operating voltages. In such cases, check out the common supply buses with the VoltOhmyst and also look for trouble in the agc circuits and in the power supply. Do not attempt to make any adjustments in the rf or if-alignment components until after the source of trouble has been eliminated.

Intermittent Troubles

Intermittent troubles in the sound- and picture-if amplifiers can often be detected by using the VoltOhmyst as a voltage monitor, as shown in Figure 8. Tune the TV receiver to a station or feed a modulated signal from an alignment generator into the front end. The VoltOhmyst can be used to measure the rectified signal across the load resistors because the signal is demodulated at these points and appears as a dc voltage. In the circuit of Figure 8, if the intermittent is located in the video amplifier, the picture will be affected, but the voltages read across both the picture and sound load resistors will be unaffected. If the trouble is located in the picture-if section, both the picture and the reading on the VoltOhmyst will be affected. In most

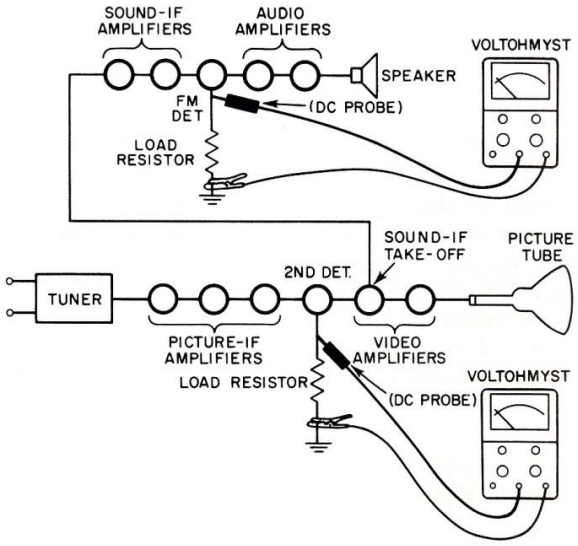


Figure 8. Monitoring signal voltages in sound- and picture-if amplifiers.

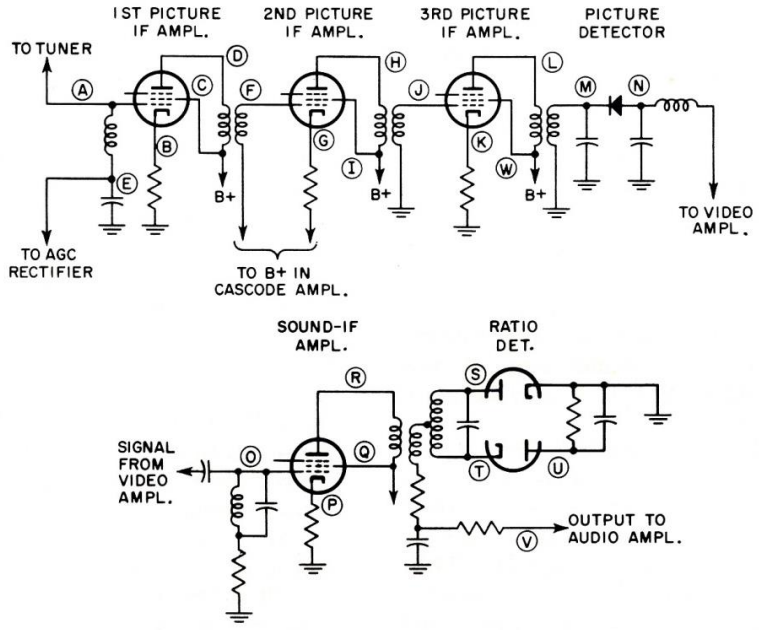


Figure 7. Simplified diagram of a picture- and sound-if amplifier showing VoltOhmyst test points.

cases, the signal to the sound-if amplifier will also be affected. If the intermittent affects the sound from the speaker and the voltage reading across the sound load resistor remains unchanged, look for trouble in the audio section. A change in sound level accompanied by a change in voltage output at the FM detector indicates trouble in the sound-if amplifier.

Troubleshooting Synchronizing and Deflection Circuits

Troubles in the synchronizing circuit are best attacked by first making voltages measurements at all the tube pins and then following up with resistance measurements with the VoltOhmyst. Changes in resistance values or a leaky, changed-value or open capacitor in any of the sync circuits can cause erratic sync action or complete loss of sync. The components are best checked out with the VoltOhmyst as described under "Testing and Troubleshooting Components".

An oscillator stage is best checked with the VoltOhmyst by measuring the developed dc grid voltage. The voltage is negative and may range from a few volts to 80 or 90 volts. The amount of voltage developed is a direct indication of how well the oscillator stage is functioning. If the measured voltage is lower than normal, look for trouble in the oscillator stage.

Troubleshooting the horizontal deflection and high-voltage output stage requires some special considerations when taking voltage measurements. A typical horizontal circuit is shown in simplified form in Figure 9. Some of the common symptoms of troubles in this section are:

1. no raster or dim raster
2. insufficient width
3. insufficient height
4. soft picture detail

These symptoms are directly related to picture brightness (a high-voltage function) and to raster dimensions (scanning function). Failure of V1 or V2 usually results in no raster because no high-voltage is available. Damper tube failure may affect brightness and raster size. Sweep may also be affected by V1 and V2.

If tube substitution fails to clear up the trouble, check the B+ voltage with the VoltOhmyst to make sure the power supply is not the source of trouble. In the circuit of Figure 9, the dc voltages at points A, B, C, D, E, F, and G should then be measured. The dc voltage at the grid of the horizontal output tube, V1, is usually negative, and varies with the setting of the drive control.

Do not attempt to measure ac voltages at points X, Y, and Z. The high impedance of these circuits produces very high ac voltages which cannot be measured with the VoltOhmyst. The high dc voltage at point H can be measured with the VoltOhmyst if a high-voltage probe is used.

Troubleshooting the Video Amplifier

The video amplifier sections may use one or two stages of simple design and may be preceded by a noise cancellation stage. The output of the amplifier is fed to either the grid or cathode of the picture tube. Troubleshooting in the video section with the VoltOhmyst consists mostly of voltage measurements at tube-socket terminals, followed by resistance measurements.

Keep in mind that troubles in the video section can affect other sections of the receiver. For example, the sound take-off point in many receivers is located in the first video-amplifier stage. The signal to the agc rectifier may also be taken from the video amplifier. Because the video amplifier must pass all the video information, these stages usually

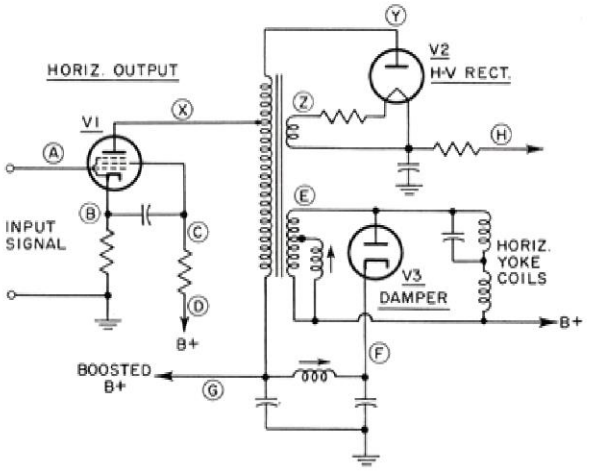


Figure 9. Simplified diagram of a horizontal-deflection and high-voltage output stage.

contain one or two peaking coils which help increase the bandpass. Do not overlook the peaking coils when making resistance checks. These coils may also be checked by dc voltage measurements.

Checking for a Defective Picture Tube

The most common symptoms of a defective picture tube are excessive warmup time, gradually increasing brightness over the operating period, lack of proper brightness with full high voltage, and a washed-out picture. A positive test may be made with the VoltOhmyst as follows:

1. Turn on the receiver and check to see that the picture-tube filament is lighted. Check adjustment of the ion-trap and focusing magnets.
2. If the picture-tube heater is not lighted, remove the socket from the tube and check continuity between the tube heater pins with the VoltOhmyst.
3. Measure the dc voltages to ground at the picture-tube socket terminals. Vary the setting of the brightness control and note the effect on the grid- and cathode-voltage readings. The grid should always be negative with respect to the cathode.
4. Check for ac video voltage at the grid or cathode terminal of the tube socket.
5. Replace the tube socket and measure the high voltage with a high-voltage probe. Vary the brightness control and note the effect on the high voltage.
6. If high voltage is lower than normal, measure the B+ and boosted B+. If B+ voltage is normal and the boosted B+ is low, install a new damper tube and remeasure the boosted voltage. If this doesn't help, install new tubes in the horizontal oscillator and horizontal-deflection-output stages.
7. If B+ and boosted B+ voltages are both normal, install a new high-voltage rectifier tube.

If none of these tests indicate other possible trouble sources, it may be concluded that the picture tube is faulty.

Radio Receiver Troubleshooting

Checking for Open Heaters

Although a defective tube in a receiver utilizing a series heater-string arrangement is usually found by tube substitution or by tube testing, the VoltOhmyst can be used to locate the open heater speedily if the chassis is out of the cabinet. The procedure, which is shown in Figure 10, is as follows:

1. Remove power from the receiver. *Caution:* To provide additional protection from electrical shock, use an Isolation Transformer, such as the RCA Isotap, when working with any type of transformerless receiver. If the VoltOhmyst ground cable is connected to any part of a transformerless receiver, it is possible for the ground cable and, in some VoltOhmysts, the instrument case to be at a potential above ground.
2. Set the range selector to a range which covers the line voltage. Connect the VoltOhmyst ground cable and ac probe across the heater pins of the first tube in the string, such as V1 in Figure 10. Apply power to the receiver. If the heater of V1 is good, no voltage will be measured.

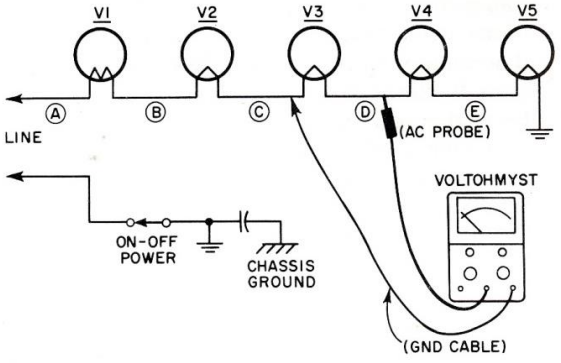


Figure 10. Locating an open heater in a series-heater string.

3. Remove power from the receiver and connect the VoltOhmyst ground and ac cables across the next tube in the string. Repeat the measurement process for each tube in the string. When the VoltOhmyst is connected across the defective heater a voltage will be indicated. In the case shown in Figure 10, the VoltOhmyst will read nearly the full value of the line voltage if the heater of V3 is open.

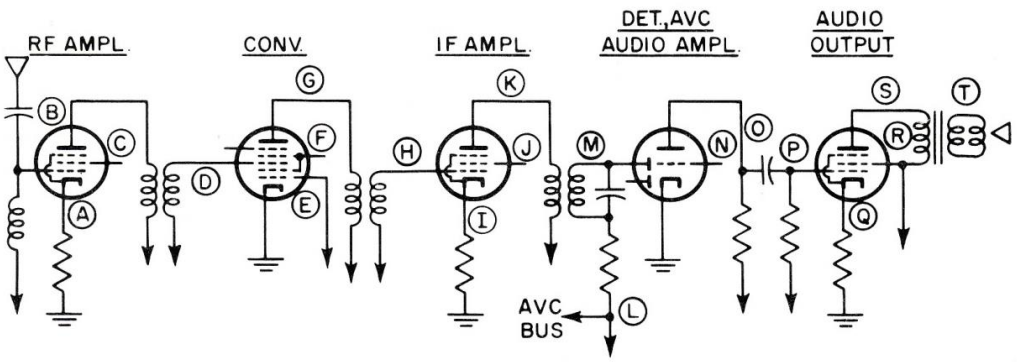


Figure 11. Simplified diagram of a typical radio receiver showing VoltOhmyst test points.

The VoltOhmyst can be used to check for a gassy tube which otherwise might pass a conventional tube test. In a resistance-capacitance coupled amplifier, a gassy tube may cause a positive bias to be developed at the grid of the tube.

The check can be made as shown in Figure 11. Set up the VoltOhmyst for dc-voltage measurements on its lowest range and measure the bias from the grid-pin to ground. Except in special applications, a positive voltage reading indicates a possible defective tube.

Troubleshooting by Voltage Measurements

One of the most effective methods of locating a defective stage in a receiver is by means of voltage measurements. The schematic diagram of Figure 11 shows, in a simplified manner, a typical five-tube radio receiver. VoltOhmyst test points are indicated by letters.

Some receivers do not employ an rf-amplifier stage and the incoming signal is fed directly to a converter stage which serves as a combined detector and oscillator. The dc operating voltages used in most radio receivers will be shown in the manufacturer's service notes for the receiver.

Keep in mind that in the superheterodyne type of receiver, the local oscillator frequency beats with the frequency of the incoming signal in the converter stage to produce an intermediate frequency which is fed, in turn, to the if amplifier. If the oscillator section of the receiver is defective, no intermediate frequency will be produced and, consequently, no output is possible.

The VoltOhmyst can be used to check the oscillator section for proper operation as follows. Set up the VoltOhmyst for "—" dc-voltage measurements on its lowest range. Measure the bias developed at the oscillator grid terminal of the converter or oscillator tube. This voltage should be in the order of 1 to 10 volts. In the circuit of Figure 11, this voltage will be checked at point **E**.

Because of the isolating resistor in the dc probe of the VoltOhmyst, it is possible to make dc-voltage measurements in the operating circuits of the receiver without upsetting normal operation. Only a few minutes are required to check the dc voltages of all the tubes. In the receiver shown in Figure 11, the dc voltages should be checked at points B, C, F, G, J, K, O, R, and S. Typical voltage values will range from 75 to 130 volts. Cathode bias, which is always positive, can be measured at points A, I, and Q. If an input signal is applied, from either a tuned-in station or from a signal generator, the avc voltage can be checked at point **L**.

Grid bias can be measured at points D, H, N, and P. If a signal of sufficient strength is fed into the receiver, the ac signal can be measured at points O, P, and S with the ac probe of the VoltOhmyst. In cases where the receiver will not pass a signal fed into the front end, the VoltOhmyst can be used as a signal tracer in the audio stages to detect the progress of the ac signal. In the circuit of Figure 11, the signal can be checked successively at points N, O, P, S, and T to determine the source of trouble.

Hum Troubles

When hum is encountered in the receiver, determine first whether it is originating in the power supply or in the signal-handling section of the receiver. If the hum originates in a stage ahead of the volume control, the hum level should change as the control is rotated. If the hum is not tunable, check the ac ripple voltage at the output of the power supply with the ac probe of the VoltOhmyst. If excessive ripple voltage is found, check for a leaking filter capacitor or for a rectifier tube with excessive heater-to-cathode leakage. Although the

VoltOhmyst can measure resistance values up to 1000 megohms, the best check for a defective tube is replacement in the socket with a good tube. Heater-to-cathode leakage as high as several hundred megohms in a rectifier tube can produce considerable hum.

RF and IF Alignment

A receiver may get out of alignment because of component aging or because parts have been replaced and the previous alignment has been upset. Symptoms of receiver misalignment are:

1. Whistling between or on stations (similar to the effect produced by oscillation).
2. Constant hiss, except on very strong stations.
3. Weak signals throughout entire tuning range, or weak signals or no signals throughout part of the tuning range.
4. No signals.
5. Dial out of calibration.
6. Receiver tunes only part of signal in at one end of band—cannot tune in other stations on extreme ends of the band.

In most cases, these complaints can be corrected by merely "touching up" one or more of the if transformers and trimmers in the oscillator and rf stages.

Although receivers vary considerably in design and the number of alignment adjustments provided, the procedure and recommendations which follow can be used on most AM radios. In addition to a VoltOhmyst, an rf signal generator is required. The generator should have a shielded output cable, an adjustable-output attenuator to permit setting the signal at the desired level, and internal modulation. If a transformerless receiver is to be aligned, an isolation transformer should be used.

Before starting alignment, disable the avc circuit to prevent the avc voltage from affecting the gain of the front end and the if amplifiers. In some cases, it is possible to perform alignment without disconnecting the avc if the input signal from the generator is kept at a low level.

The if amplifier is aligned first, as follows:

1. Disable the avc circuit and tune the receiver to a quiet spot at the high end of the dial. Put the oscillator out of operation by shorting the oscillator tuning-capacitor plates.

2. Set up the VoltOhmyst for ac voltage measurements on a low range and connect the VoltOhmyst across the speaker voice coil.

3. Connect the ground cable of the signal generator to the chassis or ground bus of the receiver. Connect the output cable to the signal grid pin of the converter tube, shown as point A in Figure 12. It is sometimes sufficient to clip the cable to the insulation of the grid lead.

4. Turn the receiver volume control to its maximum volume position and set the output from the signal generator at a low level. Set the generator dial to the intermediate frequency of the receiver (usually 455 kc). If the receiver is not completely misaligned, a small voltage will be read on the VoltOhmyst.

5. Starting with the secondary of the last if transformer, adjust the slug in L11 with an insulated screwdriver for maximum voltage reading on the VoltOhmyst. If the amplifier

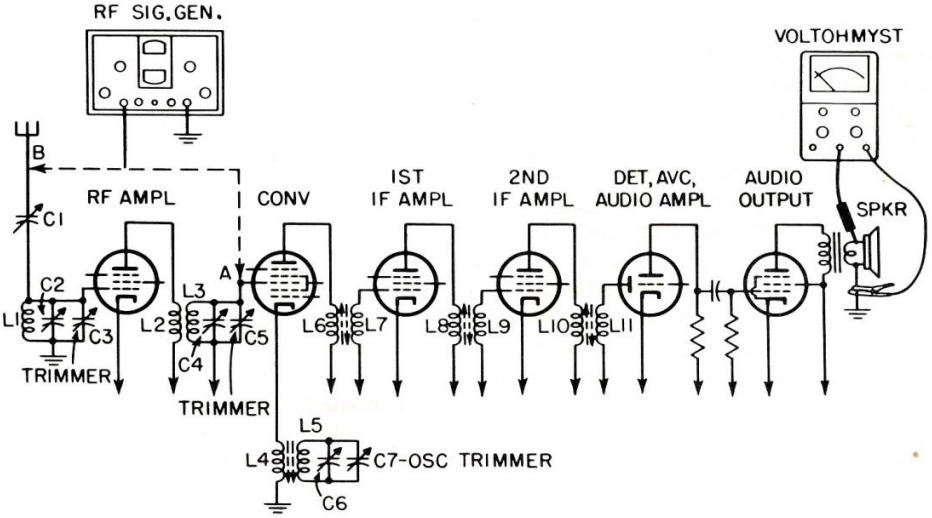


Figure 12. Test setup for aligning an AM radio receiver.

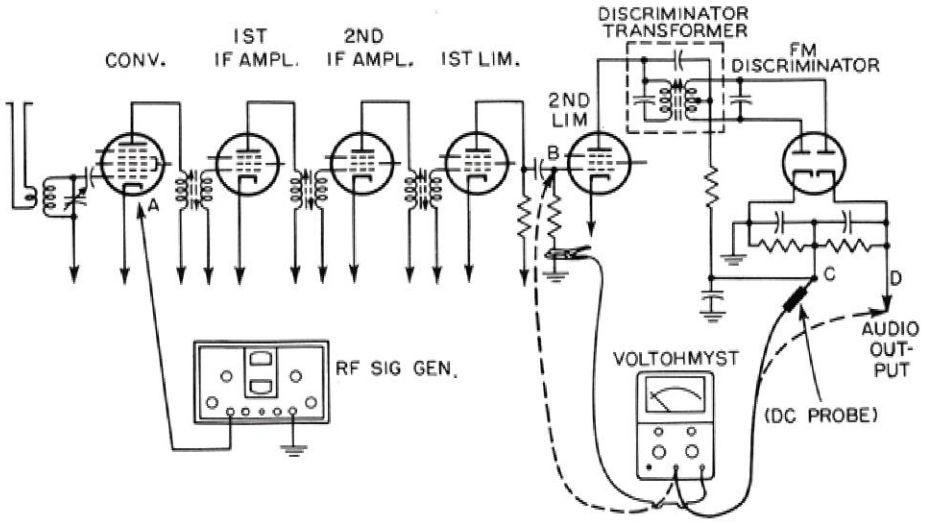


Figure 13. Test setup for aligning an FM radio receiver having a discriminator detector.

stage is operating correctly, it should be possible to tune the slug through a voltage peak on the VoltOhmyst.

6. Working toward the converter stage, similarly adjust the slugs for L10, L9, L8, L7, and L6 for maximum voltage output. Keep the injected signal from the generator as low as possible while still obtaining a voltage reading on the VoltOhmyst in order to avoid overloading the if-amplifier stage. The if amplifiers are now aligned.
7. Remove the short from the oscillator tuning capacitor and move the output cable to the antenna terminal (point B). If the receiver employs a built-in antenna, install the chassis in the receiver cabinet, if possible, before making rf adjustments. Tune the signal generator and the receiver to 1400 Kc.
8. Adjust the oscillator trimmer C7 for maximum reading on the VoltOhmyst.
9. Retune the generator and the receiver to 1600 Kc and adjust the rf-amplifier trimmer C3 and antenna trimmer C1 for maximum voltage output.
10. Retune the generator and the receiver to 600 Kc. Adjust the oscillator tuning slug in L5 for maximum output on the VoltOhmyst. Rock the tuning capacitor back and forth while making this adjustment.
11. Repeat steps 8, 9, and 10, if necessary, to get precise alignment. If this procedure is followed, the receiver should track well throughout the band.

Discriminator Detector Alignment

The test setup for alignment of a typical FM receiver having a discriminator detector is shown in the simplified diagram of Figure 13. Some FM receivers will employ an rf-amplifier stage ahead of the converter; others only a single limiter stage before the detector. The alignment procedure is as follows:

1. Tune the rf-signal generator to the receiver intermediate frequency (10.7 Mc) and connect the output cable to the shield of the converter tube (point A). Lift the shield from the chassis to prevent shorting the signal to ground. Set the generator output control to a low level.
2. Set up the VoltOhmyst for "—" dc voltage measurements on a low range and connect the dc probe to the grid resistor of the limiter stage (point B).
3. Adjust the secondary of the third if transformer with an insulated alignment tool for maximum voltage reading on the VoltOhmyst.
4. Adjust the primary tuning of the third if transformer for maximum voltage indication.
5. Similarly adjust the tuning of the second and first if transformers, working from secondary to primary windings and toward the converter stage. Keep signal level from the generator low to avoid overloading. The if amplifier should now be properly aligned.

6. Move the dc probe of the VoltOhmyst to point C. Detune the secondary of the discriminator transformer slightly and tune the primary winding for maximum negative voltage reading on the VoltOhmyst. Disconnect the dc probe from point C.
7. Rotate the zero-adjust control on the VoltOhmyst to position the meter pointer at the center-scale zero. Connect the dc probe to point D in the discriminator.
8. Carefully tune the secondary of the discriminator transformer for an exact zero-center reading on the VoltOhmyst. To avoid hand-capacitance effects, use a long-handled, nonmetallic alignment tool.

Ratio Detector Alignment

Receivers which employ ratio detectors do not usually employ a limiter stage preceding the detector, although in some receivers the last if stage provides limiting to a small extent. The if-amplifier and ratio-detector stages are aligned by observing voltage changes only in the detector stage.

A balanced ratio detector circuit is shown in Figure 14. Alignment of this type of circuit is made as follows.

1. Tune the rf-signal generator to the receiver intermediate frequency (10.7 Mc) and connect the output cable to the shield of the converter tube (point A Figure 13). Lift the shield from the chassis to prevent shorting the signal to ground. Set the generator output control to a low level.
2. Set up the VoltOhmyst for negative dc-voltage measurements and connect the dc probe to point A Figure 14.
3. Align the if transformers as described in steps 3, 4 and 5 under "Discriminator Detectors."

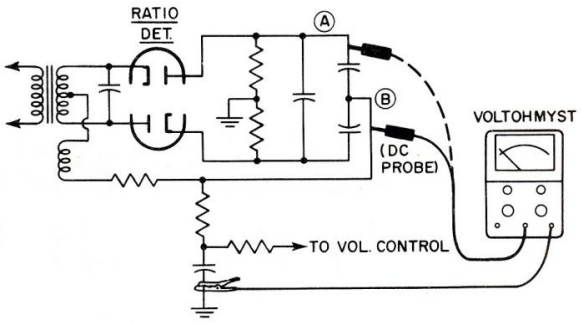


Figure 14. Simplified diagram of a ratio-detector circuit showing VoltOhmyst test points.

4. Tune the primary of the ratio detector transformer for maximum voltage reading on the VoltOhmyst at point A. Disconnect the dc probe.
5. Rotate the zero-adjust control on the VoltOhmyst to position the meter pointer at the center-scale zero. Connect the dc probe to point B.
6. Adjust the secondary of the ratio-detector transformer for a zero-center reading.

The unbalanced type of ratio detector is aligned with the same procedure, except for step 5. The VoltOhmyst is left at a low range of "—" dc volts and the secondary of the discriminator transformer is adjusted for a minimum dc voltage reading. This procedure is recommended because unbalanced detectors usually cannot be adjusted for an exact zero-center reading. For the unbalanced type of circuit, two resistors of about 56,000 ohms are connected across the ratio detector load resistor in series, during adjustment. A center tap is thus available for alignment.

Servicing and Troubleshooting Audio Equipment

The VoltOhmyst is extremely useful in audio servicing. The techniques used involve the same basic measurements used with other types of equipment. DC operating voltages are checked first, and when a defective stage is located, resistance measurements are made to isolate the defective component. If an audio-signal generator is available, the VoltOhmyst can be used to trace the input signal through individual stages of the amplifier. Here is a good procedure to follow in troubleshooting a defective amplifier with the VoltOhmyst and a generator.

1. Set up the audio-signal generator to deliver a signal within the response range of the amplifier, such as 400 cps. Connect the output cable of the generator to the input jack of the amplifier.
2. Set the amplifier input switch to the position corresponding to the channel being tested. Set the volume control at a suitable level.
3. Set up the VoltOhmyst for ac-voltage measurements on a low range and connect the ground clip to the amplifier chassis. Connect the ac probe to the grid of the first amplifier tube. A voltage reading at this point indicates that the input signal is getting through the input circuit.
4. Move the probe to the plate pin of the amplifier stage. The voltage reading should increase, indicating that the stage is functioning.
5. Check interstage coupling by moving the ac probe to the grid pin of the next stage. Check output of this stage at the plate pin. The approximate voltage gain of this stage, as well as other amplifier stages, may be computed by dividing the value of the ac signal at the plate by the value of ac grid signal.
6. Move the ac probe to the grid pin of the next tube. Rotate the treble and bass controls and note the effect upon the voltage reading. Similarly check the output signal at the plate. Repeat this check for any additional amplifier stages.
7. Check the driving signal on the grid pins of the phase inverter. The output signals at the plate and cathode pins should be approximately equal if the tube and circuit components are operating correctly.
8. Check the ac signal at the grid and plate pins of the output tubes. Measure the output signal across the speaker voice coil.

If the VoltOhmyst readings at any point indicate that gain is reduced or that the signal is lost, look for trouble between that point and the last test point at which a signal was measured. Note that some tone-control circuits have very little or no gain. Check the dc operating voltages first, then follow through with resistance readings of suspected components.

Frequency-Response Measurements

It is general practice to plot five curves on an amplifier which contains tone-control circuits. Individual curves are plotted with tone controls set for flat response and for maximum and minimum

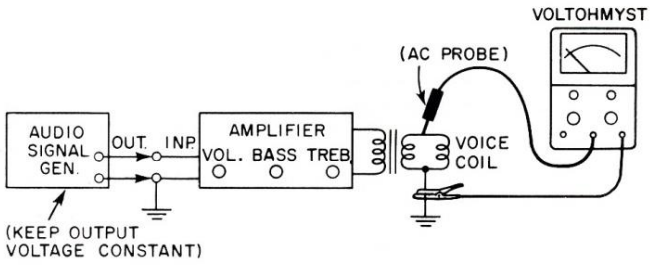


Figure 15. Test setup for frequency-response measurements.

bass and treble response. The test for flat response can be made first. In addition to the VoltOhmyst, an audio signal generator is required. The procedure is as follows.

1. Set up the VoltOhmyst, the amplifier, and the signal generator as shown in Figure 15.
2. Set the amplifier volume control to a position which corresponds to the power output level at which the test is to be made.
3. With a signal of the desired voltage applied to the amplifier input, set the tone controls to have a minimum effect on the frequency response of the amplifier. On some amplifiers, the "flat" positions for these controls are indicated. In other cases, the points of minimum effect will have to be determined experimentally.

4. Tune the generator to a frequency just below the estimated bass limit of the amplifier. With the VoltOhmyst connected across the speaker voice coil, record the ac-voltage reading.
5. Tune the signal generator to the next highest frequency at which the measurement is to be made. Record the VoltOhmyst reading. Below 200 cps, a reading can be taken every 20 cycles. The interval can be increased to 1000 cycles when readings begin to level off. Keep the audio-generator output constant for all test frequencies.
6. Tune the generator to a frequency in the treble range (3000 cps is a good starting point). Vary the bass control and note the effect on the output voltage. Similarly vary the treble control. If the treble control produces a large voltage change, lower the frequency of the audio generator. Alternately vary the bass and treble controls and adjust the frequency of the generator until a frequency is found at which both bass and treble controls have minimum effect on the output voltage. This frequency can be used as a reference frequency for plotting a curve of output voltage vs. frequency. The effect of varying the bass control should be plotted from the lower limit of the amplifier up to the reference level, while the effect of varying the treble control should be plotted from the reference frequency to the upper frequency limit of the amplifier.

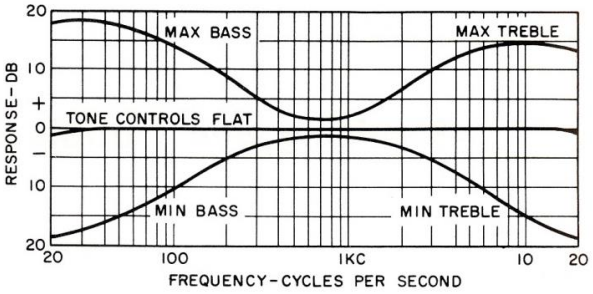


Figure 16. Typical-tone control response curves.

From the voltage readings obtained, curves such as those shown in Figure 16 may be plotted. These curves may be plotted in decibel units so that comparison of the results can be seen.

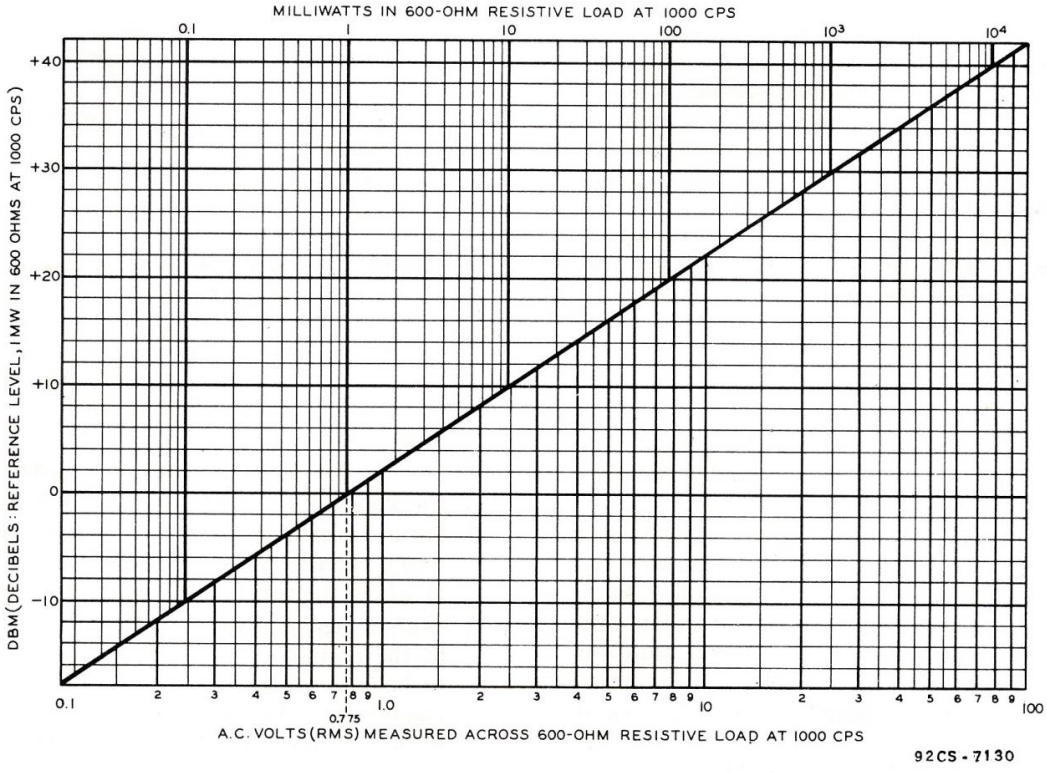


Figure 17. Graph for conversion of rms voltages to dbm values.

Graph for Conversion of RMS Voltages to DBM Values

The graph in Figure 17 can be used to determine dbm values corresponding to ac-voltage readings (rms) across a 600-ohm resistive load. A dbm value is defined as the number of decibels above or below a zero reference level of 1 milliwatt in 600 ohms at 1000 cps. Zero dbm, therefore, would indicate a power level of 1 milliwatt; 10 dbm, 10 milliwatts; and 20 dbm, 100 milliwatts.

The graph makes possible rapid conversion of rms voltages to corresponding dbm values. Associated power levels can be read along the top of the graph. If the rms voltage is measured across a resistive load other than 600 ohms, the correction factor from Figure 18 must be added algebraically to the dbm values read from the graph in Figure 17.

Resistive Load at 1000 cps	DBM*
600	0
500	+0.8
300	+3.0
250	+3.8
150	+6.0
50	+10.8
15	+16.0
8	+18.8
3.2	+22.7

*DBM is the increment to be added algebraically to the dbm value read from Figure 17.

Figure 18. Correction factors for typical resistive loads.

For resistive loads not given in Figure 18, the following formula can be used for determining the correction factor:

$$\text{Correction factor}: \ 10 \log \frac{600}{R}$$

where R is the load in ohms. If R is greater than 600 ohms, the correction factor is negative.

In many measurements, such as those on very low-level preamplifiers, it is necessary to use such a small input-signal voltage that it is difficult to measure. In such applications, a larger signal voltage which can be measured easily can be applied across a resistance attenuator, as shown in Figure 19. The ratio of resistance R2 to R1 is 100 and corresponds to the voltage ratios between the two

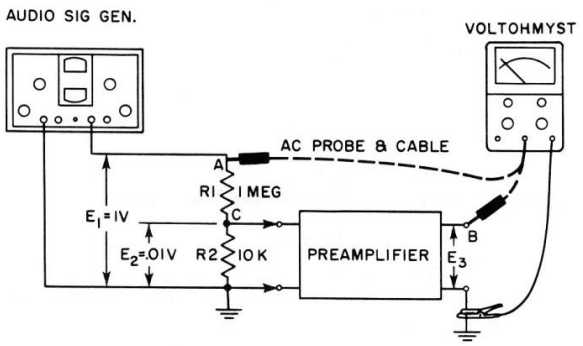


Figure 19. Test setup for obtaining small signal voltages.

resistors. The generator is set to the high impedance output and the VoltOhmyst set up for ac-voltage measurements and connected to point A.

Assume that an input voltage of 0.01 volt is required at the amplifier. The output control on the generator is adjusted for a reading of 1.0 volt at point A. If resistance ratios are correct, 0.01 volt will be obtained at point C. The ac probe of the VoltOhmyst is then moved to point B and the output voltage measured.

Troubleshooting Tape Recorders

The tape recorder presents two distinctly different approaches to servicing; mechanical servicing and electrical servicing. Mechanical problems usually result in wow and flutter, improper winding and tape breakage. Generally, these troubles are the result of dirt or wear on belts, rubber drive wheels, clutches and pressure pads, or worn or loose parts. It is unusual to find a broken part in a tape recorder. Because of the variety of tape recorders, it is best to check the mechanical operation of the recorder according to the manufacturer's service notes.

The electrical portion of the tape recorder may be also considered to be composed of two sections, the recording and the reproducing sections.

The recording section consists of the input circuits, the recording, playback and erase heads and their associated circuits; and the bias and erase oscillator. The input circuits can be checked with the "Ohms" function of the VoltOhmyst; the operating voltages, with the "dc" voltage function. Figure 20 shows a simplified schematic of a tape recorder. The dc voltage at each of the points C, D, E, and F in Figure 20A (playback mode) are usually higher than the voltages at points G, H, J, and K (record mode). In addition, voltage is

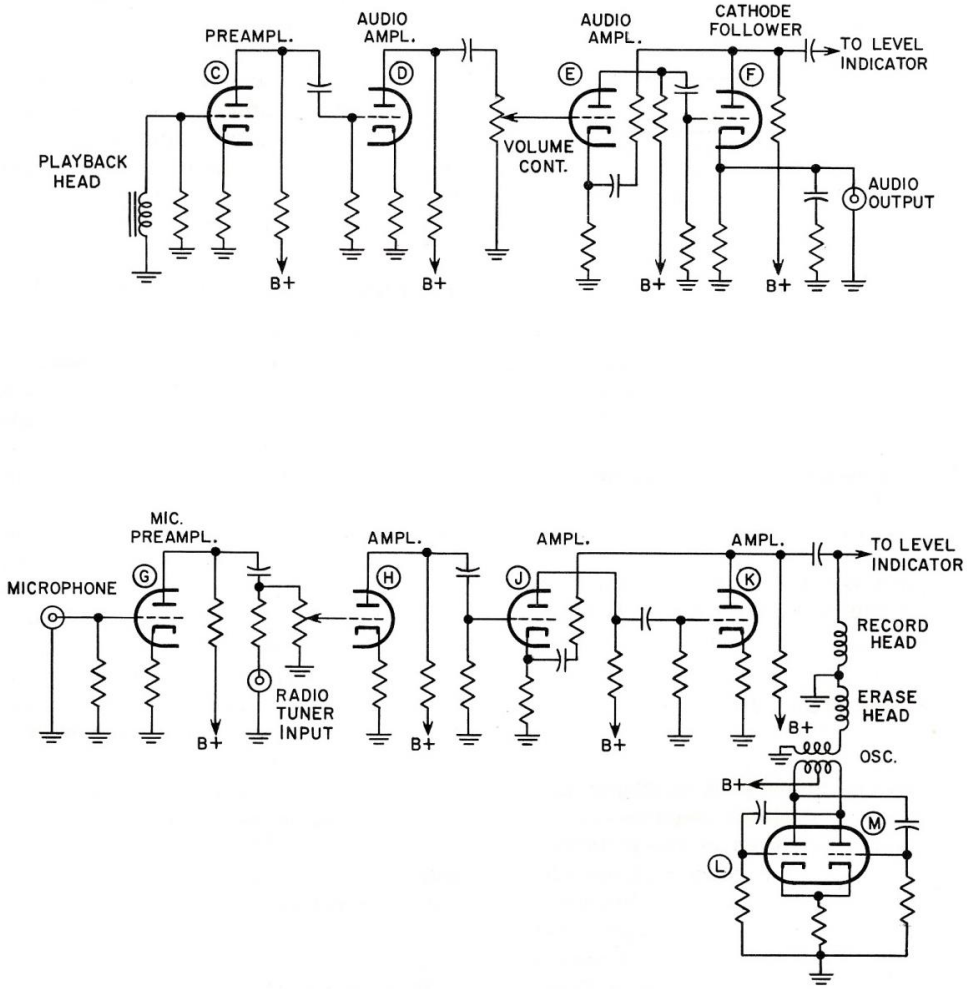
applied to points L and M in the oscillator circuit only during the record mode.

The amplifier used in tape recorders may be serviced using the same techniques employed in servicing audio amplifiers.

Tape Guide and Head Alignment

Improper tape guide position or head alignment can cause a variety of symptoms, some of which may be mistaken for troubles in the amplifier or oscillator sections. Troubles which may result from head misalignment include poor high-frequency response, incomplete erasure, loss of volume, and overlapping in multiple track recorders.

Because the specific method for making tape-guide and head-alignment adjustments is different in different tape recorders, the instructions provided by the manufacturer should be followed. The general procedure, outlined below, may be used with most tape recorders. A test tape is required for proper adjustment of the tape guides and for proper head alignment. Standard frequency tapes such as the RCA-12-5-61T are commercially available for this purpose. The tape should be in motion while these tests are being made.



b — Record mode.

Figure 20. Simplified diagram of a typical tape recorder.
a — Playback mode b — Record mode.

Tape-Guide Adjustment

1. Connect the VoltOhmyst across the voice coil of the speaker or across the output terminals of the tape recorder.
2. While playing the 1000-cps section of the test tape, adjust the tape guide on the supply-reel side of the recorder for maximum output on the meter. Adjust the vertical position of the tape guide so that tape does not bind or rub against the upper or lower edge of the guide.
3. Position the other tape guide so that the tape is level. Always check head alignment after making tape-guide adjustment.

Head Alignment

Since head misalignment seriously effects high-frequency response, head alignment is best checked by using a high-frequency signal.

A test frequency of at least 10,000 cps should be used for best results.

1. With the VoltOhmyst connected across the output of the recorder play the high-frequency section of the tape.
2. Adjust the azimuth alignment screws for the angular position of the head which gives the highest output. On recorders which have a provision for separate vertical adjustments, position the head according to the manufacturer's instructions.

Troubleshooting Stereophonic Systems

Basically the stereo system consists of a program source, a left- and a right- channel amplifier and two speakers. In some cases, both amplifiers are on the same chassis and have a common power supply. In this type of equipment, if the same trouble exists in both channels, it is probable that the trouble originates in the program source or in the power supply. If the trouble exists in one channel only, check the amplifier as indicated in the section "Audio Servicing." In systems having two separate amplifiers, each amplifier may be treated as a separate unit with only the program source common to both units.

Balancing Stereophonic Systems

For proper operation, the output level of each channel of a stereo system should be equal. Single chassis stereo amplifiers usually incorporate balance controls. The manufacturer's instructions should be followed in making balance adjustments. A typical method for balancing the two channels follows:-

1. Connect the output of a monaural signal source, such as an audio signal generator or a test record, to both the right and left channel inputs. Use a frequency of 1000 cps as a test frequency.
2. Set both balance controls for maximum output.
3. With the speakers connected measure the voltage developed across the voice coil of speaker in each channel, with the VoltOhmyst.
4. Connect the VoltOhmyst across the voice coil of the speaker with the higher output and adjust the corresponding balance control so that the voltage is equal to that of the lower channel.

Some amplifiers have a single equalizing control. In these amplifiers only one channel can be adjusted. The method for balancing is similar to the one given in Step 4 above. Measure the output of the channel which does not have the control, then adjust the control to provide the same output level from the second channel.

Stereo systems utilizing two separate amplifiers may not have a balance control. To equalize the outputs of this system, the volume controls should be used to balance the system.

1. Connect the output of a monaural signal source, such as an audio signal generator or a test record to both amplifier inputs.
2. Adjust the volume controls so that the desired volume is obtained.
3. Measure the output across the voice coil of each speaker, and adjust the volume controls so that the outputs are equal and at the desired volume level.
4. Mark the position of the volume control setting on the front panel.

Miscellaneous Applications

Measuring High Voltages

DC voltages up to 50000 volts can be measured with the VoltOhmyst when auxiliary High-Voltage Probes such as the WG-289 or the WG-297 are used. These probes are equipped with a high-voltage multiplier resistor which provides an additional multiplying factor of 100 for the reading shown on the dc-voltage scales of the VoltOhmyst.

Measurement of Power-Supply Ripple

The filtering action of power-supply filters may be determined easily by measuring the ac component at the output of the filter with the VoltOhmyst, as shown in Figure 21. Set up the VoltOhmyst for ac voltage measurements on a low range, connect the ground cable to the negative side of the filter section, and connect the ac probe to the positive.

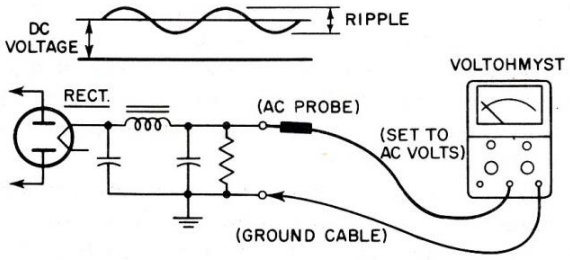


Figure 21. Measuring ripple voltage.

Because of its ability to measure ac voltage in the presence of dc, the VoltOhmyst will indicate value of the ripple voltage.

Checking Battery Voltages

The output voltages of nearly every type of battery can be checked accurately with the VoltOhmyst *if a suitable load is attached to the battery.* Battery voltages should always be measured with the battery under its customary load, either in the equipment in which the battery is installed or across a suitable resistance load. In the case of portable radios, the voltage should be measured with batteries connected to the receiver and the power switch turned on. If the batteries are not installed in the receiver, a suitable external resistance should be temporarily connected across the output terminals.

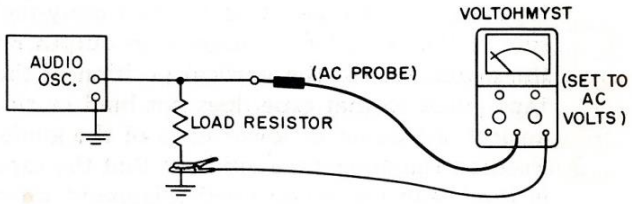


Figure 22. Test setup for measuring output-signal voltages.

Calibrating Voltage Output of Generators and Oscillators

The test setup shown in Figure 22 can be used for making output measurements from such test equipment as signal generators and oscillators. A suitable load resistor should be connected across the output terminals of the generator and the attenuator set to give the desired voltage output at a predetermined reference frequency.

Voltage readings should be taken, with the VoltOhmyst set for ac-voltage measurements, at intervals throughout the tuning range of the generator. The ac probe should be used for all audio and low-frequency rf measurements. For rf measurements, the VoltOhmyst should be set to "—" dc volts and an rf probe used in conjunction with the dc probe.

A well-designed generator should have essentially flat voltage output throughout its rated frequency range if the correct load resistance is used.

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